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The Hyperspectral Operational Support Tool (HOST) user interface evaluation:

Preliminary heuristic analysis results

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Defence R&D Canada
Technical Note
DRDC Toronto TN 2008-172
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Abstract

This document presents a preliminary heuristic evaluation of the Hyperspectral Operational Support Tool (HOST) v3.0a user interface, which was designed for hyperspectral imagery analysts. Results of the interface evaluation recommend two main problem areas to address: first, enforcing a more structured file and image management convention; and second, creating a tighter mapping between objects in the control window and visualization window. A solution would be to utilize a layered image file or project file to address these problems, although either of these solutions may require developers to move away from the Environment for Visualizing Images (ENVI) platform upon which the HOST is currently based. The design of the user interface could benefit from additional independent evaluations, a large scale usability test and a formal task analysis with Subject Matter Experts.

Résumé

Ce document présente une évaluation heuristique préliminaire de l'interface usager du « Hyperspectral Operational Support Tool » v3.0a, qui a été développé pour des analystes de l'imagerie hyperspectrale. Il y a deux principaux types de problèmes à résoudre: Premièrement, adopter une méthode de gestion plus structurée des fichiers et des images et deuxièmement, créer une relation plus étroite entre les objets de la fenêtre de contrôle et de la fenêtre de visualisation. Une solution possible est d'utiliser des fichiers projets ou images à plusieurs niveaux pour adresser ces problèmes bien qu'il fut déterminé que ces approches pourraient demander aux développeurs de ne plus utiliser la plate-forme ENVI sous laquelle « Hyperspectral Operational Support Tool » est présentement développé. La conception de l'interface usager pourrait de plus bénéficier de multiples évaluations indépendantes, d'une évaluation d'utilisabilité à plus grande échelle et d'une analyse formelle des tâches par des experts du domaine.

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Executive summary

HOST user interface evaluation: Preliminary heuristic analysis results

Kevin Trinh; Matthew Lamb; DRDC Toronto TN 2008-172; Defence R&D Canada – Toronto.

Introduction or background: The Hyperspectral Operational Support Tool (HOST) serves as an interactive analysis environment for hyperspectral imagery analysts. A preliminary heuristic interface evaluation of HOST v3.0a was conducted considering the user interface with reference to a fixed set of usability heuristics derived from a factor analysis of many usability problems.

The ten (10) heuristics included:

- Visibility of system status,
- Match between system and real world,
- User control and freedom,
- Consistency and standards,
- Error prevention,
- Recognition rather than recall,
- Flexibility and efficiency of use,
- Aesthetic and minimalist design,
- Help users recognize, diagnose and recover from errors, and
- Help and documentation.

Results: There remain two main problem areas to address: first, enforcing a more structured file and image management convention; and secondly, creating a tighter mapping between objects in the control and visualization windows. A solution may be to utilize a layered image file or project file to address these problems though it is recognised that either of these solutions may require developers to move away from the HOST's existing platform.

Significance: The recommendations provided could result in greater user satisfaction, improved performance, fewer errors and adoption of the HOST into operational use.

Future plans: The design of the user interface could further benefit from multiple independent evaluations, a large scale usability test and a formal task analysis with subject matter experts.

Sommaire

HOST user interface evaluation: Preliminary heuristic analysis results

Kevin Trinh; Matthew Lamb; DRDC Toronto TN 2008-172; Defence R&D Canada – Toronto.

Introduction ou contexte: Le "Hyperspectral Operational Support Tool (HOST)" est utilisé comme un environnement d'analyse interactive pour les analystes de l'imagerie hyperspectrale. Une analyse heuristique préliminaire de l'interface de HOST v3.0a en utilisant les techniques heuristiques de Neilsen a été réalisée. Cette analyse a été réalisé en considérant l'interface usager en fonction d'un ensemble prédéterminé d'heuristiques d'utilisabilité dérivé d'une analyse factorielle de nombreux problèmes d'utilisabilité.

Les 10 heuristiques inclues sont:

- Visibilité de l'état du système
- La correspondance entre le système et le monde réel
- Le contrôle de l'usager et sa liberté
- Consistence et standards
- Prevention des erreurs
- Reconnaitre plus tôt que rappeler
- Flexibilité et efficacité à l'usage
- Esthétique et interface minimaliste
- Aider l'usager à reconnaître, diagnostiquer et récupérer des erreurs; et
- Aide et documentation.

Résultats: Il y a deux principaux types de problèmes à résoudre: Premièrement, adapter une méthode de gestion plus structurée des fichiers et des images et deuxièmement, créer une relation plus étroite entre les objets de la fenêtre de contrôle et de la fenêtre de visualisation. Une solution possible est d'utiliser des fichiers projets ou images à plusieurs niveaux pour adresser ces problèmes bien qu'il fut déterminé que ces approches pourraient demander au développeurs de ne plus utiliser la plate-forme ENVI sous laquelle HOST est présentement développé

Importance: Les recommandations fournies pourrait mener à une plus grande satisfaction de l'usager, une performance amélioré et l'adoption de HOST pour une utilisation opérationnelle.

Perspectives: La réalisation de l'interface usager pourrait de plus bénéficier de multiples évaluations indépendantes, d'une évaluation d'utilisabilité à plus grande échelle et d'une analyse formelle de tâches par des experts du domaine.

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1 Background

This document presents the findings and recommendations of a heuristic user interface evaluation of the Hyperspectral Operational Support Tool (HOST) v3.0a. The evaluators were approached by Dr. Jean-Pierre Ardouin, Defence Research and Development Canada (DRDC) Valcartier), the Project Manager of the HYperspectral iMage EXploitation (HYMEX) Technology Demonstration Program (TDP), to offer advice on the usability of the HOST prototype after the first design cycle iteration. It is anticipated that the recommendations of this report will to be considered as requirements for future design iterations by MacDonald, Dettwiler and Associates Ltd. (MDA; Richmond, BC), the software designers.

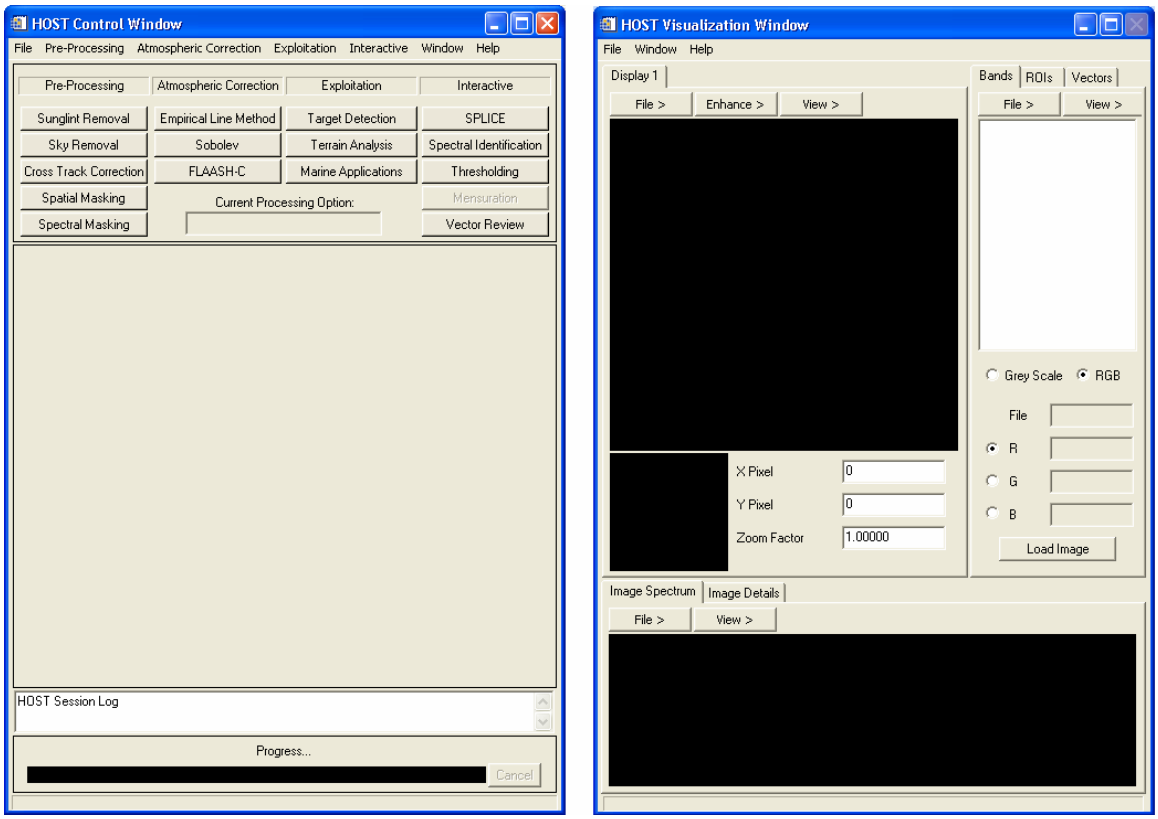
The authors were first introduced to HOST v1.0 in April 2007 via a brief video conference demonstration of the core functions and anticipated interaction sequences. Citing a need to interact directly with the HOST and view the interface at a higher resolution, the evaluators were provided with a trial version of the ENvironment for Visualizing Images (ENVI) + Interactive Data Language (IDL) v4.3 to evaluate the software at DRDC Toronto. A preliminary informal analysis was conducted in July 2007 by repeating the target detection demonstration using notes from the previous video conferences and documentation in the HOST User's Guide [1]. The demonstration consisted of four main steps: 1. Applying the Empirical Line Method (ELM) tool to imagery, 2. Performing target detection using one of the algorithms provided, 3. Manually thresholding an image, and 4. Exploring the Vector Layer Viewer tool. While working through the demonstration, the interface was evaluated using Nielsen's usability heuristics [2]. Results of the preliminary analysis were considered for the current alpha version of HOST (v3.0a) (herein abbreviated as simply HOST).

This evaluation is limited by the number of evaluators from which the results were obtained and their experience going through tutorials #1 and #2 in the current HOST Tutorial documentation [3]. The design of the user interface could further benefit from multiple independent evaluations, a large scale usability test and a formal task analysis with subject matter experts (SMEs). It also would have been useful for the evaluators to have had a better understanding of the typical user tasks and situations. Walk-through tutorials were provided with the current version of the HOST tool. The authors' working assumption was that this software will serve as an interactive analysis environment for hyperspectral imagery analysts.

2 Overview of the HOST Interface

The HOST has been designed as a plug-in to International Telephone & Telegraph (ITT) Visual Information Solutions' ENVI to demonstrate various hyperspectral imagery algorithms for applications in target detection and identification, terrain categorization and mapping, and marine applications. *Figure 1a* shows the control window available upon launching the HOST. The menu has a unique button for each tool in the application. The tools are grouped in columns from left to right in an anticipated order of use. The HOST Control Window allows a user to select individual processing options, input processing parameters, and view displays of session information and processing status.

The HOST Visualization Window (*Figure 1b*) allows for the display and manipulation of images, plots, image bands, region of interests (ROIs), and vector files. This window is divided into three main sections: The Display tab to the upper left; the Bands, ROIs and Vectors tabs to the upper right; and the Image Spectrum, Image Details, and Thresholding tabs (not shown) at the bottom of the interface. The Display tab displays the hyperspectral imagery that is being manipulated. The Bands, ROIs and Vectors tabs are tools used to either select regions within the imagery or display overlays on top of the imagery. The Image Spectrum, Image Details, and Thresholding tabs contain image spectrum graphs, metadata about the imagery and the thresholding tool, respectively.



a b

Figure 1. a) HOST Control Window. b) HOST Visualization Window.

3 Application of Nielsen's usability heuristics to the HOST

This section provides an assessment of the Host interface against Neilsen's ten usability heuristics [2]. For each heuristic, relevant system components are identified and recommendations for improvement are provided when warranted.

1. Visibility of system status. "The system should always keep users informed about what is going on, through appropriate feedback within reasonable time".

HOST: The HOST appears fine in this regard.

Recommendation: None at this time.

2. Match between system and the real world. "The system should speak the users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order".

HOST: The first encounter with the HOST is a window with buttons designed for quick access to the tools available for image analysis. The tools are grouped under four main headings: Pre-Processing, Atmospheric Correction, Exploitation and Interactive. The order of these groups helps guide users through a typical progression of hyperspectral image treatments. Users are still free to utilize tools in any order.

Recommendation: None at this time.

3. User control and freedom. "Users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue. Support undo and redo".

HOST: In the tools reviewed, overwriting output files is possible and irreversible. When setting algorithm parameters and browsing to an existing file for output, the system prompts the user with a warning message. However, if after an algorithm is run with different parameters, say an input file is changed, there is no warning that the existing output file would be overwritten.

Recommendation: A check for overwrite should happen upon clicking "Run Algorithm".

4. Consistency and standards. "Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions".

HOST: The current version of the HOST represents a major improvement to previous versions which followed the ENVI default windows with pop-up windows for each image, graph and sub-tool. In the current version, the HOST groups relevant displays into one

visualization window with sets of tabs as in *Figure 1b*. This helps create a consistent and predictable interface with dedicated screen real-estate for each display.

Proper labelling of graphs and images are a problem for the HOST. This may be a limitation inherent in the underlying ENVI platform. For example, in the ELM tool, radiance plots should show units of measure for the wavelength and radiance axes. There does not appear to be any conversion between screen coordinates and geo-referenced latitude and longitude coordinates. This latter example may be due to classification restrictions. It is also unclear why probabilities appear as negative values in some Image Spectrum graphs.

Recommendation: Radiance plots in the ELM tool should show units of measure for the wavelength and radiance axes. Latitude and longitude coordinates should be displayed. Probabilities should be positive values in the Image Spectrum graphs.

5. Error prevention. "Even better than good error messages is a careful design which prevents a problem from occurring in the first place. Either eliminate error-prone conditions or check for them and present users with a confirmation option before they commit to the action".

HOST: As mentioned earlier, there have been some major interface improvements in HOST v3.0a. One problem that persists, however, is the generic naming of Display tabs such as "Display 1" or "Display 2". These labels do not afford the content of the tab. Image details can be found in the lower groups of tabs but this is not linked with the Display tab. It is unclear with the visualization window whether or not the right group of tabs (Bands/ROIs/Vectors) and lower group of tabs (Image Spectrum, Image Details, Thresholding) belong to the currently selected Display tab.

Recommendation: The right and lower tab groups should be nested into the Display tab. Tabs should be labelled with unique, relevant and recognisable keywords. In the control window, the input forms for each tool require data validation to ensure errors such as missed fields get caught before users run processes. This might be achieved by emphasizing required fields, checking for file overwrites, or disabling the "Run Process" button until the required data have been entered.

6. Recognition rather than recall. "Minimize the user's memory load by making objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate".

HOST: The main image file extension used in the HOST is .dat. Dat files are used to represent output image files from the ELM, Target Detection, and Score Cube Classifier tools. Users may be confused when sorting through .dat files because they do not encode the history of the tools from which they were created. By default, the HOST appends suffixes to file names to help recall which tools and parameters were used to create them. However, this convention is not enforced by the system and may lead to inconsistent file-naming conventions across users.

Recommendation: Output files from different tools should be given unique extensions, or have intra-file meta-tags applied, to help recognize and filter them as appropriate input files for other tools. Alternatively, all images associated with an original source image could be packaged into a single file with layers of tool output images.

Recommendation: In the control window, image previews may be useful for file identification. For the ELM function, it would be useful to show previews for reference spectra before selecting them from the library. This could be done as a wavelength/radiance graph to help visually identify the spectra.

Recommendation: When spectral graphs are shown, associated wavelength colors for the visible spectrum could also be shown in the axes via coloured text or a parallel coloured line.

HOST: Due to the potential of vector overlap, it may be difficult to count selected vectors when using the Manual Thresholding tool. This information is available in the Vector Layer tool, but can only be accessed after the thresholding process is complete.

Recommendation: In addition to the existing broad map view of the highlighted vectors, displaying the number of vectors selected within the Manual Thresholding tool would help users reach their target vector counts.

7. Flexibility and efficiency of use. "Accelerators – unseen by the novice user – may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions".

HOST: Algorithm processing may take several minutes. When running several processes in sequence, processing time prevents users from setting the parameters of the next action. Batch scripts can be programmed to run algorithms automatically; however, there is concern about the robustness of the current scripting implementation. For example, one identified problem occurred when a single base image was subjected to a series of processes where the outputs from a process were used as inputs to the next. Since the validation of the entire batch script happens before any processing begins, script errors occur when the validate function searches for input files that have not yet been created from processes in the queue.

Recommendation: Validation of batch scripts should allow for dependencies between steps or the validation of each step should occur immediately before that step is to be performed.

HOST: To help users locate HOST files, a default folder location for HOST outputs can be defined in the HOST preference settings. For a given image this is a convenient feature that helps users organize their work. However, it may also prove cumbersome with multiple input files and output folders.

Recommendation: Due to the variety of outputs and inputs used within the HOST, along with the possibility of numerous analysis permutations, it may be useful to have its own file explorer instead of relying on the Windows Explorer. A file management structure like SigmaPlot's[1] worksheet/notebook is an option worth considering.

[1] SigmaPlot is a spreadsheet graphing software: http://www.sigmaplot.com/products/sigmaplot/sigmaplot-details.php#a1

8. Aesthetic and minimalist design. "Dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility".

HOST: Issues with the visualization window have been identified in Heuristic 5.

Recommendation: It is recommended that the right group of tabs (Bands/ROIs/Vectors) and lower group of tabs (Image Spectrum, Image Details, Thresholding) be nested for each Display tab. Tabs should only be visible when their function is applicable.

9. Help users recognize, diagnose, and recover from errors. "Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution".

HOST: Log files document all actions and responses from the user and system. Messages are typically descriptive but do not necessarily provide solutions or reasons for errors when they occur.

Recommendation: In addition to displaying error messages, it would be useful if some guidance was provided to help users diagnose and resolve errors. This may be in the form of a checklist or a step-by-step wizard. To help visually filter critical and important messages, different fonts or text colors can be employed within the log text.

10. Help and documentation. "Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the user's task, list concrete steps to be carried out, and not be too large".

HOST: Use and terminology documentation is provided.

Recommendation: The provision of typical use scenarios would be beneficial for first-time users.

HOST: One assumption of the HOST is that its users are well-versed hyperspectral imagery analysts which may not always be the case.

Recommendation: Documentation describing the purpose of each function as well as expected input and outputs would help provide or reinforce basic analyst training for the novice user. It would also help connect the user's knowledge and training with the HOST suite of tools. On the same note, describing some of the underlying theories behind parameters and algorithms can help the user develop an appreciation for the capabilities of the tool.

4 Other Comments

Thus far, we have identified issues specific to and common amongst the HOST tools. We are conscious that the HOST has been developed to demonstrate a proof-of-concept suite of analytical tools. Advancements to the interface have been made in v3.0a over previous versions to streamline workflow, but the future of the HOST as a tool used by Canadian Forces hyperspectral imagery analysts could be improved through formal evaluation and task analysis with SMEs. In the meantime, there remain two main problem areas that can be addressed: enforcing a more structured file and image management convention (we have previously suggested unique file names or meta-tagging, yet will propose two other remedies); and creating a tighter mapping between objects in the control and visualization windows.

The current HOST file management solution works well if a single user employs all required tools for a particular task within a single session. However, there are many possible scenarios where multiple users access common input images over multiple days and sessions. Using a unique file extension for different tool outputs or meta-tagging files to help identify algorithms and parameters that were used to create them, as we have suggested, would help, but implementing a unique HOST layered file type would further improve file management. This file could include the raw input image but also superimpose algorithm output layers such as atmospheric corrections, vector thresholding, terrain analysis and target detection. Parameters for the algorithms could be logged or tagged with the layers produced. This solution is similar to the layered Adobe Photoshop[2] .psd file.

An alternative solution would be to implement a wrapper project file that links a set of related files and incorporates their parameters and meta-data. This has the advantage of leaving file types as they are and not generating possible excessively large layered files. This would also allow user projects to share image resources, thereby minimizing duplication. To provide support for external tools and applications, an export feature could be implemented within the HOST. This solution is similar to Microsoft Visual C++ 2008[3] project files .sln or .vcproj.

Subscribing to one of the suggestions for file management will likely support a tighter mapping between objects in the two main HOST windows. For example, a project file could contain all necessary input and output parameters for each image file. This would presumably link the information in the control window with displays in the visualization window. HOST would likely benefit from a parent-child windowing solution found in commercial products such as Adobe Photoshop or Microsoft Visual C++ 2008 where dedicated screen real estate is used for a project (or layer) management frame. This may require the HOST to be decoupled from the ENVI environment.

[2] Adobe Photoshop is an image processing software:
http://www.adobe.com/products/photoshop/photoshop/
[3] Microsoft Visual C++ 2008 is an integrated development environment for writing C++ code:
http://msdn.microsoft.com/en-ca/visualc/aa336447.aspx

5 Conclusions and Recommendations

This report presented a preliminary heuristic evaluation of HOST v3.0a based on Nielsen's heuristics. The following recommendations should be considered to improve the usability of the HOST:

- Checks for empty fields and warnings for file overwrites should be implemented before running algorithms;
- Labelling of plots, graphs and window tabs should be improved;
- File and image management must be addressed through unique file extensions or packaged files with layers with a tailored file explorer integrated into HOST;
- Documentation and typical use scenarios is recommended for novice users;
- The Bands, ROIs, and Vectors group of tabs and the Image Spectrum, Image Details, and Thresholding tabs should be nested for each Display tab;
- Image and reference spectra previews are recommended when selecting from a folder or library;
- Batch scripts should allow for dependencies between steps;
- Error messages should be accompanied by guidance to help users diagnose and resolve errors;
- Revisit user information requirements and ensure important information is available and made salient as appropriate; and
- A formal user testing session and task analysis is recommended to ensure the HOST will meet the needs of its intended users.

6 Acronyms and Abbreviations

DRDC	Defence Research and Development Canada
ELM	Empirical Line Method
ENVI	ENvironment for Visualizing Images
HOST	Hyperspectral Operational Support Tool
HYMEX	HYperspectral iMage EXploitation
IDL	Interactive Data Language
ITT	International Telephone & Telegraph
MDA	MacDonald, Dettwiler and Associates
ROI	Region Of Interest
SME	Subject Matter Expert
TDP	Technology Demonstration Program

References

[1] MacDonald Dettwiler and Associates (2007). Hyperspectral Operational Support Tool: User's Guide, report under DRDC contract W7701-5-2350

[2] Nielsen, J. (1994). Heuristic evaluation. In J. Nielsen & R. L. Mack (Eds.) Usability inspection methods (pp. 25-103). New York: Wiley.

[3] MacDonald Dettwiler and Associates, (2008). Hyperspectral Operational Support Tool: Host v2.0 Tutorial, report under DRDC contract W7701-5-2350

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(U) ENVI; HOST; hyperspectral imagery analysis; interface; heuristic evaluation

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